Petroleum Refining Protocol Discussion Paper

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Agenda

- Introduction
  - Role of California Climate Action Registry
  - Discussion paper objectives
- GHG sources and methodologies
  - Source prioritization
  - Method options for major sources
- Facility definition
  - Co-located operations
  - Reporting considerations
- Q & A

Role of the California Registry

- Overall:
  - Support the development of AB32 reporting rules
- Specifically:
  - Inform the discussion of existing Registry reporting methods
  - Inform the discussion of other national & international best practices

Discussion Paper Objectives

- Serve as a reference for the petroleum refining sector technical workgroup
- Provide information on
  - The refining sector in California
  - Boundary considerations (e.g., defining a facility)
  - GHG source identification (and relative emissions contribution)
  - GHG calculation methodology options
  - QA/QC
- Serve as a starting point for developing a Climate Registry *voluntary* reporting protocol

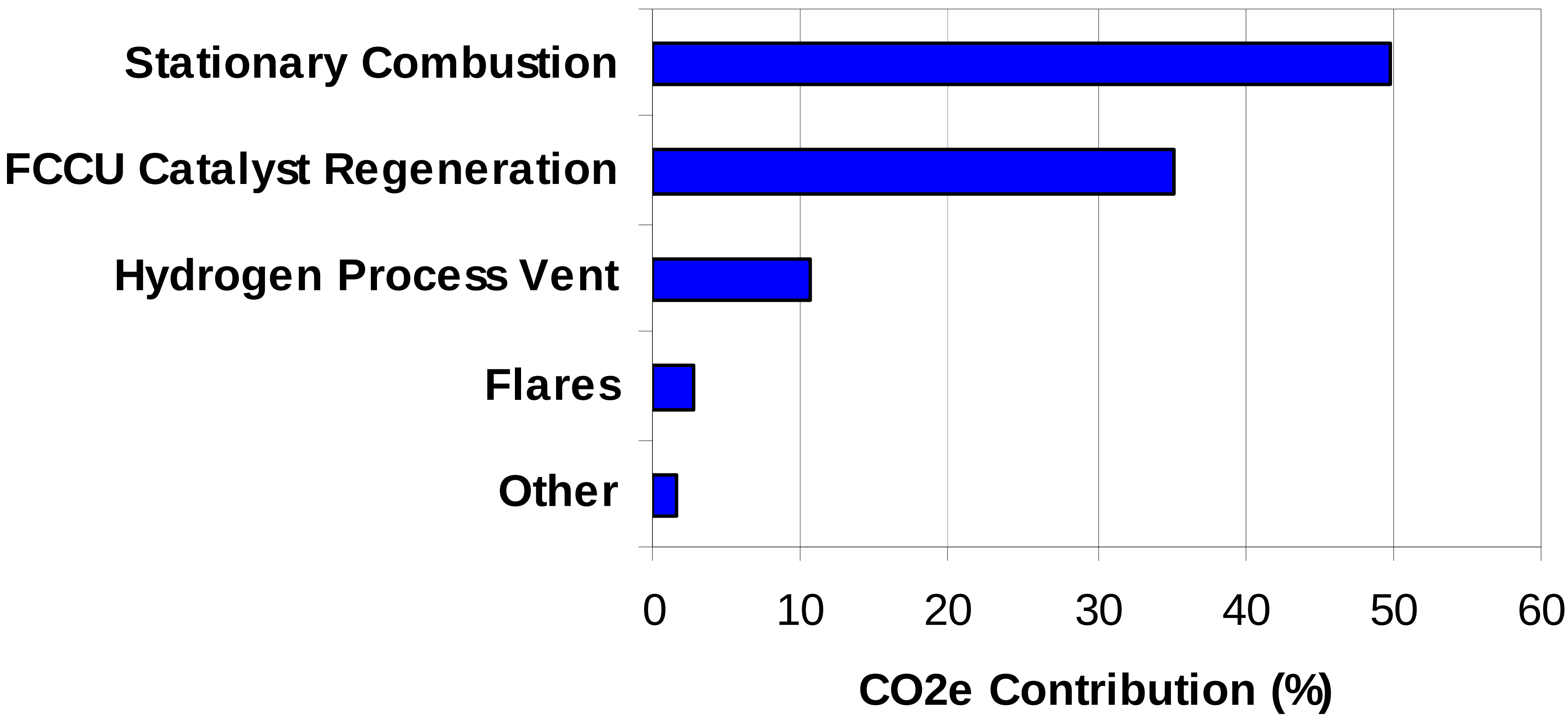
GHG Sources & Method Options

GHG Source Prioritization

Source Type	Source	Percent Contribution to Total CO_2 Equivalent Emissions		
		CO_2	CH_4	N_2O
Combustion Sources	External combustion	42.3	3.9 E-3	7.1 E-2
	Internal combustion	7.4	1.7 E-1	5.6 E-1
	Flares[a]	2.8	1.2 E-4	0
	Incinerators	0.3	3.0 E-5	5.5 E-4
	Combustion Total	**52.9**	**1.8 E-1**	**6.3 E-1**
Vented sources	Hydrogen plant vents	10.7	0	0
	Catalytic cracking regeneration vent	35.2	0	0
	Storage tanks	0	Negligible	0
	Loading / transit	0	0	0
	Vented Total	**45.9**	**0**	**0**
Fugitive Sources	Fugitive components	Negligible	?[b]	0
	Fugitive Total	Negligible	Negligible	0
Indirect Sources	Electricity purchased	5.8 E-1	2.6 E-4	2.7 E-2
	Indirect Total	5.8 E-1	2.6 E-4	2.7 E-2

Source: API Compendium, Table 7-24, 2004

GHG Major Sources



Method Options

- Options for estimation methodologies for major sources
  - Stationary combustion
    - Refinery fuel gas
    - Flaring
  - Process emissions
    - FCCU catalyst regeneration
    - H_2 production
  - Fugitive emissions

Method Accuracy Ratings

Petroleum Refining Guidance:

- API Compendium
  - Preferred approach
  - Alternate approach
- IPIECA Guidelines
  - Tier A: +/- 5-10% uncertainty
  - Tier B: +/- 10-15%
  - Tier C: +/- 15-30%
- EU ETS
  - Tier 3: highest accuracy
  - Tier 1: lowest

General Guidance:

- DOE 1605(b)
  - Tier A: highest accuracy
  - Tier D: lowest

Combustion: Fuel-Based Material Balance Approach

$CO_2 = f$(Fuel usage, MW, Carbon Content, Oxidation Factor)

- Data Required
  - Fuel consumption
  - Fuel composition
- Accuracy Rating
  - Highest
    - IPIECA rating depends on sample frequency

- Advantages
  - High accuracy
  - RFG composition generally measured
- Disadvantages
  - Sample frequency commensurate with variabiliy
  - Data collection and management

Fuel-Based Heating Value Approach

$CO_2 = f$[Fuel usage, EF (lb CO_2/Btu), HHV]

- Data Required
  - Fuel consumption
  - Fuel heating value
- Accuracy Rating
  - Compendium:
    - Alternate approach
  - EU ETS:
    - Tier 2

- Advantages
  - More accurate than simple emission factor approach
- Disadvantages
  - Default factors based on assumed carbon content
  - RFG characteristics for refineries in CA different than average US refinery

CARB Proposed Approach for RFG

EF_{CO2} (lb CO_2/Btu) =f(Carbon Content, HHV, MW) (Daily)

CO_2 =f(Fuel Usage, EF_{CO2}, HHV) (Hourly)

- Procedure:
  - Daily composition to derive EF
  - Apply daily EF to hourly HHV to estimate CO_2
- Data Required
  - Fuel consumption
  - Daily fuel composition
  - Hourly heating value

CARB Proposed Approach for RFG

- Advantages
  - High accuracy
  - Data to assess fuel composition variability
- Disadvantages
  - High sample frequency
  - Data collection and management resource intensive
  - Verification more data intensive

- Considerations:
  - Materiality, especially when more than one RFG system is employed
  - Variability of composition over time
  - Sample size vs. improved accuracy
  - Resource requirements for sampling, analysis, data archiving and management, reporting, and verification

RFG Sampling Frequency

- Precedents – EU ETS
  - Minimum sampling frequency of RFG is at least daily, using appropriate procedures at different parts of the day.
  - If available, evidence that the derived samples are representative and free of bias.
  - Annual average derived emission factor has a maximum uncertainty of less than one-third of the maximum uncertainty in the associated activity data based on the reporting tier.

Flaring: Fuel-based Material Balance

CO_2 =f(Vol. Flared, Carbon Content, Combustion Efficiency)

CH_4 =f(Vol. Flared, CH_4 Fraction, Un-oxidized CH_4)

- CO_2 Combustion Efficiency:
  - API Compendium: 98%
  - EU ETS: 99.5%
- Methane Destruction Efficiency:
  - Un-oxidized methane: 0.5%

- Alternate Approaches:
  - Volume flared estimated
  - Carbon content estimated

Process: CCU Catalyst Regeneration

Coke Burn Rate Method

CO_2 =f(Coke Burn, Coke Carbon Fraction)

Coke Burn =f(%CO_2, %CO, %O_2, Vol. Exhaust, Vol. Air, etc.)

- Data Required
  - Coke carbon fraction
  - Exhaust gas measurements
- Accuracy Rating
  - Compendium: Preferred
  - IPIECA: Tier A
  - EU ETS: Tier 1

- Advantages
  - Reasonable accuracy
  - Coke burn available
- Disadvantages
  - Data intensive for coke burn estimate

Process: CCU Catalyst Regeneration

Flue Gas Composition Method

CO_2 = f(Air Rate, Supplemental O_2 Rate, %CO_2, %CO)

- Data Required
  - Air intake rate(s)
  - Exhaust gas measurements
- Accuracy Rating
  - Compendium: Preferred
  - IPIECA: Tier A
  - EU ETS: Not addressed

- Advantages
  - Reasonable accuracy
  - Requires less data than coke burn rate method
- Disadvantages
  - If exhaust rate known, can be simplified.

Process: Hydrogen Production

Feedstock Rate/Composition Method

$CO_2 = f$(Feedstock Rate, Feedstock Carbon Composition)

- Data Required
  - Feedstock rate
  - Feedstock composition
- Accuracy Rating
  - Compendium: Preferred
  - IPIECA: Tier A
  - EU ETS: Tier 2

- Considerations
  - Feedstock sampling frequency commensurate with compositional variability
  - Where PSA offgas is recycled as fuel, avoid double counting

Process: Hydrogen Production

Hydrogen Prouction Method

$CO_2 = f(H_2$ Production Rate, Feedstock Carbon Composition)

- Data Required
  - Hydrogen rate
  - Feedstock composition
- Accuracy Rating
  - Compendium: Alternate
  - IPIECA: Tier B
  - EU ETS: Not addressed

- Considerations
  - Should not be used (without modification) when RFG is feedstock
  - Should not be used where PSA offgas is recycled as fuel, unless stream is accounted for

Fugitive Emissions

- CH_4 fugitive emissions historically considered negligible for refining operations
- Recent optical infrared measurement studies have indicated higher than previously believed
  – Around 1-2% (50,000 tCO2e/yr) from average refinery
  – Major areas were vacuum distillation, delayed coker area, cooling towers, crude feed tanks

Facility Definition

Installation Definition

- PSD
  - SIC group. If the plants could have separate SICs but a support relationship exists, e.g., 50% of the product of one is utilized by the other, then one plant is considered a support facility and this criterion shall be considered met,
  - Are located on one or more contiguous or adjacent properties (in the same general area), and
  - Are under common ownership or control.
- EU ETS
  - "Installation" means a stationary technical unit where one or more activities listed in Annex I (e.g., mineral oil refining) are carried out and any other directly associated activities which have a technical connection with the activities carried out on that site and which could have an effect on emissions and pollution.

Co-Located Facilities

- Common configurations of co-located facilities
  - Hydrogen production
  - Cogeneration
  - Loading / unloading operations
  - Wastewater treatment
- Potential reporting gaps:
  - Non-combustion sources may not be reported
    - Hydrogen process emissions
    - Loading / unloading operations
    - Wastewater treatment operations

Questions?

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